

When and where	Lecture (001) NE 2103 T, R - 2:30 – 3:50 pm	Lab (002) NE 2350 T 3:55 - 5:25 pm
		Lab (003) NE 2350 R 3:55 - 5:25 pm
Instructor	Prof. Wm Ted Evans, PhD, PE (Ohio)-Office: NE 1607, Phone 419-530-3349, cell 419-343-3681 Email: william.evans@utoledo.edu , web www.hybridplc.org	
Office Hours	9:30-12:00 M,W	
Prerequisite	Prerequisites: EET 3250 for UG with min of D- or ENGT 3050 for UG with min of D-	
Textbook	All posted on hybridplc.org website under course.	
Useful References	DiStefano et al, Schaums Outlines – Feedback and Control Systems, 2 nd ed. Astrom and Murray, Feedback Systems – An Introduction for Scientists and Engineers, v2.11b, online and at hybridplc.org website, control.com/education, Liptak, Instrument Engineers' Handbook, Process Measurement and Analysis, Process Control ISA (International Society of Automation), www.isa.org	
Grading	Homework 10 %, Quizzes 10 %, Labs 20 % Midterm exam I 20 %, Midterm exam II 20 % Completion of 20 Video Reviews 20%	
Class rules and regulations	1. No eating, drinking, or smoking in classrooms. 2. There are no make-up exams for this course. If you have a problem or conflict and cannot attend an exam, let me know beforehand and we will try to work something out. No credit will be given for a missed exam that we haven't made arrangements about beforehand unless you have a really excusable emergency. Cell phone use will not be allowed. If you do not have a calculator, buy one and bring it to class. <i>Cheating is not allowed and will be punished by rules of U of Toledo Student Handbook.</i>	
Catalog descriptions	This course is an introduction to industrial controls, including the PID control of closed-loop servo and process systems, with emphasis placed on the electronic circuits of the closed-loop sub-systems.	
Topics and reading assignments (subject to change, any changes will be notified in the class beforehand)	• To study the basic elements of an automatic control system • To use block diagrams to describe the elements of a control system • To study the difference between open-loop and closed-loop systems • To use the knowledge of math and science in deriving the process model and use it in the controller design • To determine and design signal conditioning for the system • To study the operation of different transducers/sensors and their importance in a control system • To be able to design a controller for a system to satisfy a certain performance criterion • To study the operation and performance of different control strategies such as P, PI, PD and PID • To use Bode plots to study the stability of controlled systems • To use labs for hands on experience with different measuring devices and compare different control techniques	
Class dates (Exam dates are subject to change.)	Homework assignments are listed on the website and are accepted only before or on the assigned day. Labs are to be printed from the website and brought to lab. Labs to be graded only if submitted at end of assigned class period. Pop quizzes may occur any day at the end of the class period.	

	Date	Lecture/Lab Schedule	Homewrk/Lab Due Date
Week 1	9/1/26	Intro and Terms	
	9/3/26	Instruments and Linear Conversion	
Week 2	9/8/26	Automatic Control	
	9/10/26	Intro to Laplace	HW 1
Week 3	9/15/26	Laplace Cont, Lab 2	
	9/17/26	Laplace Cont	HW 2 - Lab 1
Week 4	9/22/26	Laplace Cont, Lab 3	
	9/24/26	Laplace Cont	HW 3 thru 4.12 - Lab 2
Week 5	9/29/26	Laplace Cont, Lab 4	
	10/1/26	Boxes	HW 4 any 15 - Lab 3
Week 6	10/6/26	Boxes, Lab 5	
	10/8/26	Boxes, Laplace Review	HW 5 any 10 - Lab 4
Week 7	10/13/26	Midterm Test 1, Lab 6	
	10/15/26	Return Midterm Test 1	Lab 5, all labs, HWs due
Week 8	10/20/26	Fall Break	
	10/22/26	Bode Plot, Lab 7	HW6
Week 9	10/27/26	Measurements	Lab 6
	10/29/26	Sensors, Lab 8	
Week 10	11/3/26	Pressure and Flow	Lab 7
	11/5/26	Jim Pital – Introduction to Pneumatics Pneumatic Direction Control Valves (Full lecture)	
Week 11	11/10/26	Temperature	Lab 8
	11/12/26	Control Valves, Lab 9	HW 7
Week 12	11/17/26	Veterans Day Break	
	11/19/26	Pneumatics	Lab 9
Week 13	11/24/26	Electric Machines, Lab 10	HW 8
	11/26/26	PID Revisited – PPT 436-499	Lab 10
Week 14	12/1/26	Review, Lab 11	
	12/3/26	Review	HW 4a and 4b
Week 15	12/8/26	Test 2	Lab 11, 12
	12/10/26	Return Test and Wrap Up	
Final		Final Exam Week – Hand in Video Reviews	

Tacoma Narrows Bridge Collapse "Gallopin' Gertie"

<http://www.youtube.com/watch?v=j-zczJXSxnw>

How to Read a P&ID? (Piping & Instrumentation Diagram)

<https://www.youtube.com/watch?app=desktop&v=j4EOTerfyTY&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=1>

Kaufman

<https://www.youtube.com/watch?v=eXB2qHsVsFM&list=PLj10k9JPIMAGPAIylqEkEr-oGKIMQPsg>

What is a Fourier Transform?

<https://www.youtube.com/watch?v=wmClrpLBFds>

More information can be found on MATLAB at:

<https://rocketsutoledo.sharepoint.com/sites/ecchelp/eccwiki/ENG%20Virtual%20Labs.aspx>

Modal Testing Seminar

<https://community.sw.siemens.com/s/article/Modal-Testing-Seminar>

How to Read a Datasheet

https://www.youtube.com/watch?app=desktop&v=IWsh_lDxiUQ&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=63

Limit Switch Explained – Working Principles

<https://www.youtube.com/watch?app=desktop&v=8v7flnvKNQM&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=16>

Diode Module | How does it work?

<https://www.youtube.com/watch?app=desktop&v=gQNSpEOz5mM&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=17>

Terminal Blocks Explained

<https://www.youtube.com/watch?v=X-kZ2ksav8g&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=19>

What is a Sensor? Different Types of Sensors, Applications

<https://www.youtube.com/watch?app=desktop&v=XI49uFm5HRE&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=12>

Smart Sensor Explained | Different Types and Applications

<https://www.youtube.com/watch?app=desktop&v=5b5xJu8KYrc&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=13>

What is a Transistor | Working Principles

https://www.youtube.com/watch?app=desktop&v=YtM_MnM0qT4&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=21

Basics of the Linear Variable Differential Transformer (LVDT)

https://www.youtube.com/watch?app=desktop&v=o_hEmYip248&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=55

Photoelectric Sensor Explained (with Practical Examples)

<https://www.youtube.com/watch?app=desktop&v=l1rjErRvbgw&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=34>

Photoelectric Sensor Wiring and Setup

<https://www.youtube.com/watch?app=desktop&v=g3utyglYy0E&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=36>

3-wire Inductive Proximity Sensor | How to Read the Datasheet

<https://www.youtube.com/watch?v=DtNylZ-BGa4&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=11>

Inductive Sensor Explained | Different Types and Applications

https://www.youtube.com/watch?v=o4_6yu-GIDU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=37

Transmitter Explained | Types of Transmitters

<https://www.youtube.com/watch?v=DtNylZ-BGa4>

Pressure Sensor, Transducer, and Transmitter Explained | Application of Each

<https://www.youtube.com/watch?app=desktop&v=DVq10SGKHMU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=41>

How to Measure Flow Rate with a DP Transmitter

<https://www.youtube.com/watch?app=desktop&v=e169sklQ5Ys&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=2>

DP Flow Transmitter Testing and Recalibration

<https://www.youtube.com/watch?v=4MzFQtQOI3c&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=3>

Turbine Flow Meter Explained | Operation and Calibration

<https://www.youtube.com/watch?app=desktop&v=RvwXGzzv4c&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=29>

Ultrasonic Flow Meter Explained | Working Principles

<https://www.youtube.com/watch?app=desktop&v=JRKIR4YgMHw&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=43>

Magnetic Flow Meter Explained | Working Principles

https://www.youtube.com/watch?app=desktop&v=D999KDUj_QU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=70

Pressure Gauge Explained | Types of Gauges

https://www.youtube.com/watch?app=desktop&v=muWuIJS_F7k&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=50

Pressure Transmitter Explained | Working Principle

<https://www.youtube.com/watch?app=desktop&v=zS77qnIEPg0&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=9>

Differential Pressure Transmitter Explained

https://www.youtube.com/watch?v=XkMEto_x22A

The Differential Pressure Flow Measuring Principle (Orifice-Nozzle-Venturi)

<https://www.youtube.com/watch?v=oUd4WxjoHKY>

Manometer Explained | Working Principle

<https://www.youtube.com/watch?app=desktop&v=gxrLkLjybnA&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=20>

Pressure Switch Explained | Types of Pressure Switches

<https://www.youtube.com/watch?app=desktop&v=1VdSxSRhadM&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=33>

Bernoulli Equation

<https://www.youtube.com/watch?v=DW4rltB20h4>

DP Level Measurement Explained

<https://www.youtube.com/watch?app=desktop&v=yIhwPcyieTc&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=5&pp=iAQB>

DP Closed Vessel Level Measurement Explained

<https://www.youtube.com/watch?app=desktop&v=VyHlgqqpGEc&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=7&pp=iAQB>

Capacitive Sensor Explained | Different Types and Applications

https://www.youtube.com/watch?app=desktop&v=o4_yu-GIDU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=37

Thermocouple Explained | Working Principles

<https://www.youtube.com/watch?app=desktop&v=mNoI62URtAk&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=54>

How to Choose a Thermocouple (with Practical Examples)

<https://www.youtube.com/watch?app=desktop&v=5IS6jq6laVU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=56>

Understanding Temperature Sensor Technology: RTDs, Thermocouples, and Thermistors

<https://www.youtube.com/watch?app=desktop&v=J2uID-bPTS4&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=76>

Temperature Transmitter Explained | Connection and Calibration

<https://www.youtube.com/watch?app=desktop&v=Kq22wxqzJ7g&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=44>

What is an RTD | Working Principles

<https://www.youtube.com/watch?app=desktop&v=7nsIJ5fOLJ8&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=73>

RTD Installation and Maintenance 101: A Beginner's Guide

<https://www.youtube.com/watch?app=desktop&v=Fut1AYx0QAc&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=78>

RTD vs Thermocouple: Which is Better for Your Needs?

<https://www.youtube.com/watch?app=desktop&v=J2uID-bPTS4&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=76>

How to Wire a Thermocouple to a PLC

<https://www.youtube.com/watch?app=desktop&v=ZG574Ss56HA&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=58>

What is a Control Valve?

<https://www.youtube.com/watch?app=desktop&v=KtsiM1st0KA&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=14>

Valve Sizing

<https://www.youtube.com/watch?v=ldLkbV3W7Pk>

Festo Pneumatic Control

<https://www.youtube.com/watch?v=5q7YasmwXCc>

FluidSIM

<https://www.youtube.com/watch?v=ajLRtRs92IY>

Big Bad Tech – Jim Pytel

https://atecentral.net/r44246/pneumatic_flow_control_methods_part_1_of_2

https://atecentral.net/r44247/pneumatic_flow_control_methods_part_2_of_2

https://www.youtube.com/watch?v=zHto_QiORz0&list=PLdnqjKaksr8qM_nxfOnZhELfllr6auQZG

<https://openoregon.pressbooks.pub/hydraulics/chapter/1-2-hydraulics-math/#pb-interactive-content>

<https://openoregon.pressbooks.pub/hydraulics/>

Pytel - motor starter with jogging

<https://www.youtube.com/watch?v=jcpXV9-ww1c&list=PLdnqjKaksr8qRPCFkU2Q8XQe0bfo99rs6&index=30>

DC Motor

<https://www.youtube.com/watch?v=CWuIQ1ZSE3c>

AC Motor

https://www.youtube.com/watch?v=59HBolXzX_c

VFD

<https://www.youtube.com/watch?v=yEPe7RDtkgo>

Motor Starter Explained | Motor Starter Types

<https://www.youtube.com/watch?app=desktop&v=wEwX2PRebVU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=26>

What is a Contactor? | Working Principles

<https://www.youtube.com/watch?app=desktop&v=08ozhRb7HEU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=38>

<https://www.youtube.com/watch?app=desktop&v=08ozhRb7HEU&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=38>

Electrical Grounding Explained | Basic Concepts

<https://www.youtube.com/watch?v=YO-Dnk6ZKrl&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=32>

Variable Frequency Drives Explained | VFD Basics - Part 1

https://www.youtube.com/watch?app=desktop&v=HayryySX_po&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=57

Variable Frequency Drives Explained | VFD Basics - Part 2

<https://www.youtube.com/watch?app=desktop&v=DXjXh0cF8Kc&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=62>

Kalman Filter with Student Dave

https://www.youtube.com/watch?v=FkCT_LV9Syk

<https://www.youtube.com/watch?v=NT7nYv9Ri2Y>

What are 2-Wire and 4-Wire Transmitter Output Loops?

<https://www.youtube.com/watch?app=desktop&v=Bk5bLrzwLI&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=4>

Interpreting Typical Analog Input Control Loop Diagrams

<https://www.youtube.com/watch?app=desktop&v=fcF6ivDavRQ&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=8>

WiFi vs Industrial Wireless - What is the Difference?

<https://www.youtube.com/watch?app=desktop&v=QP8WF4UCmcw&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=22>

Pressure Transducer and Transmitter Wiring Explained

<https://www.youtube.com/watch?app=desktop&v=dt4Q69yMZY&list=PLIn3BHg93SQ9fq9jcwARIFCmrpXE2rZuj&index=53>